

NOV 29 1999

**Two New Species of *Chromodoris* (Mollusca, Nudibranchia, Chromodorididae) from Southern India, with a Redescription of *Chromodoris trimarginata* (Winckworth, 1946)**

by

**Ángel Valdés**

*Department of Invertebrate Zoology and Geology, California Academy of Sciences  
Golden Gate Park, San Francisco, California 94118*

**Ernesto Mollo**

*Istituto per la Chimica di Molecole di Interesse Biologico, CNR,  
Via Toiano 6, 80072 Arco Felice, Napoli, Italy*

and

**Jesús Ortea**

*Departamento de Biología de Organismos y Sistemas, Laboratorio de Zoología,  
Universidad de Oviedo, c/ Catedrático Rodrigo Uria s/n, 33071 Oviedo, Spain*

*Chromodoris trimarginata* (Winckworth, 1946) is redescribed on the basis of specimens from southern India. The reproductive system of this species is illustrated for the first time. New characters, such as the rhinophores and gill coloration, the width of the white marginal band, and the radular morphology, are provided to distinguish this species from the similar *Chromodoris preciosa* (Kelaart, 1858). In addition, two new species of *Chromodoris* from southern India are described. *Chromodoris mandapamensis* sp. nov. is characterized by a dorsum covered with brown spots, a broken line of bright orange around the mantle margin, very large branchial leaves, and radular teeth with large denticles. *Chromodoris naiki* sp. nov. is a pale gray species with bright orange and purple spots, and a number of white dots on the dorsum. Internally it lacks rachidian radular teeth, has long cusps in the mid lateral teeth, and lacks a vestibular gland. The external morphology and anatomy of these two species is described, and compared to other similar Indo-Pacific species.

The Chromodorididae of India and Sri Lanka (Ceylon) have received little attention compared to well studied areas in the Indo-Pacific. Few species were described in the classic papers by Alder and Hancock (1864) and Kelaart (1958; 1859a; 1859b). In the first half of the 20th century, Farran (1905), Eliot (1906a; 1906b; 1910), O'Donoghue (1932), Winckworth (1945) and White (1948) described more new species or redescribed those introduced by Kelaart or other authors. More recently, Narayanan (1969) and Rudman (1973) studied several specimens from India, providing range extensions and the description of a new species.

The present paper studies three species of the genus *Chromodoris* Alder and Hancock, 1864, collected by the second author from Mandapam (Tamil Nadu) and Muttom (Kerala), southern India. The specimens studied are deposited at the Department of Invertebrate Zoology, California Academy of Sciences, designated by the abbreviation CASIZ.

## SPECIES DESCRIPTIONS

*Chromodoris trimarginata* (Winckworth, 1946)

Figs. 1A, 2, 3

*Glossodoris trimarginata* Winckworth, 1946:156–157.*Chromodoris trimarginata* (Winckworth): Rudman, 1985:267–268, fig. 16.

MATERIAL EXAMINED. — Mandapam, Tamil Nadu, India, May 1998, two specimens 30 mm long, one of them dissected, collected by E. Mollo (CASIZ 115219); March 1999, one specimen 20 mm long, collected by E. Mollo (CASIZ 115228).

EXTERNAL MORPHOLOGY. — The body is oval to elongate (Fig. 1A). The posterior end of the foot is not covered by the notum. The living animal is pale gray, with a number of reddish spots irregularly scattered over the central part of the dorsum. At the extreme edge of the mantle there is a white, thin band, then a band of deep red and on the inside a slightly wider band of yellow. The mantle glands are situated on the inside of the yellow band and form a wide, opaque white band around the whole mantle margin. The rhinophore stalks are translucent white; the clubs are cream, and the apexes opaque white. The perfoliate rhinophores are composed of 20 lamellae. The gill consists of 11 unipinnate branchial leaves. The leaves are translucent white with opaque white lamellae.

ANATOMY. — The buccal mass is divided evenly into an anterior glandular portion and a posterior muscular one. At the posterior end of the mass there are a pair of short, elongate salivary glands. The jaws are composed of a number of elongate, bifid rodlets (Fig. 2D) about 20  $\mu$ m in length. The radular formula is 57  $\times$  53.1.53 in one specimen (CASIZ 115219) examined. The rachidian teeth are small, triangular plates. The innermost lateral teeth (Fig. 2A) have three to four denticles on the inner side of the cusp and four to five denticles on the outer side. The remaining lateral teeth (Fig. 2B) are hook-shaped, lack denticles on the inner side of the cusp and have a series of four to six denticles along the outer edge. The outer laterals (Fig. 2C) are elongate, having five to six denticles situated at the tip of the teeth.

The reproductive system (Fig. 3) has a short, tubular ampulla that divides into the oviduct and the prostate. The oviduct is short and enters the female glands near the center of the mass. The prostate is long, tightly coiled with several loops. It narrows and then expands into a long, muscular deferent duct. The deferent duct is also highly coiled, and opens into a common atrium with the vagina. The penis is unarmed. Near the exit of the female glands there is a small, saccate vestibular gland. The vagina is very long, slightly coiled. Near the end of the vagina the uterine duct emerges. It is very long and convoluted and opens into the female glands. The curved, club-shaped seminal receptacle and the elongate, thin-walled bursa copulatrix open proximally in the vaginal duct.

DISTRIBUTION. — *Chromodoris trimarginata* is only known from India; it was originally described from Bombay (Winckworth 1946) and the present record from Mandapam constitutes the second collection of this species.

REMARKS. — *Chromodoris trimarginata* was described by Winckworth (1946) in the binomen *Glossodoris trimarginata*, based on 88 specimens collected from Bombay (India). The living animals were described as being cream or very pale green with irregular reddish spots scattered over the central area. At the extreme edge of the mantle there was a white, thin band, then a band of red and on the

→





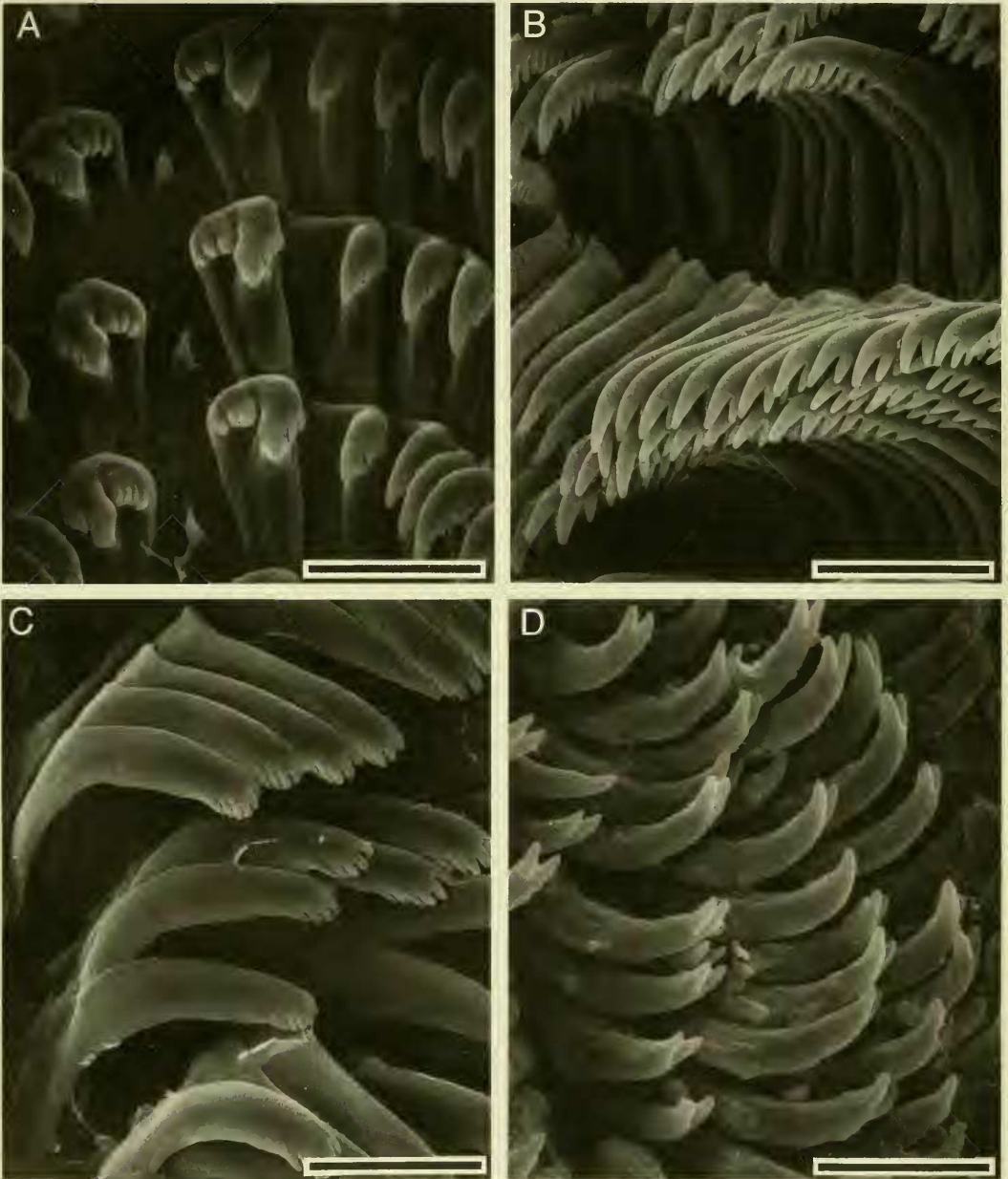


FIGURE 2. *Chromodoris trimarginata* (CASIZ 115219), scanning electron micrographs. A. Inner lateral teeth, scale bar = 25  $\mu\text{m}$ ; B. Lateral teeth from the central portion of the half-row, scale bar = 30  $\mu\text{m}$ ; C. Outer lateral teeth, scale bar = 25  $\mu\text{m}$ ; D. Jaw rodlets, scale bar = 15  $\mu\text{m}$ .

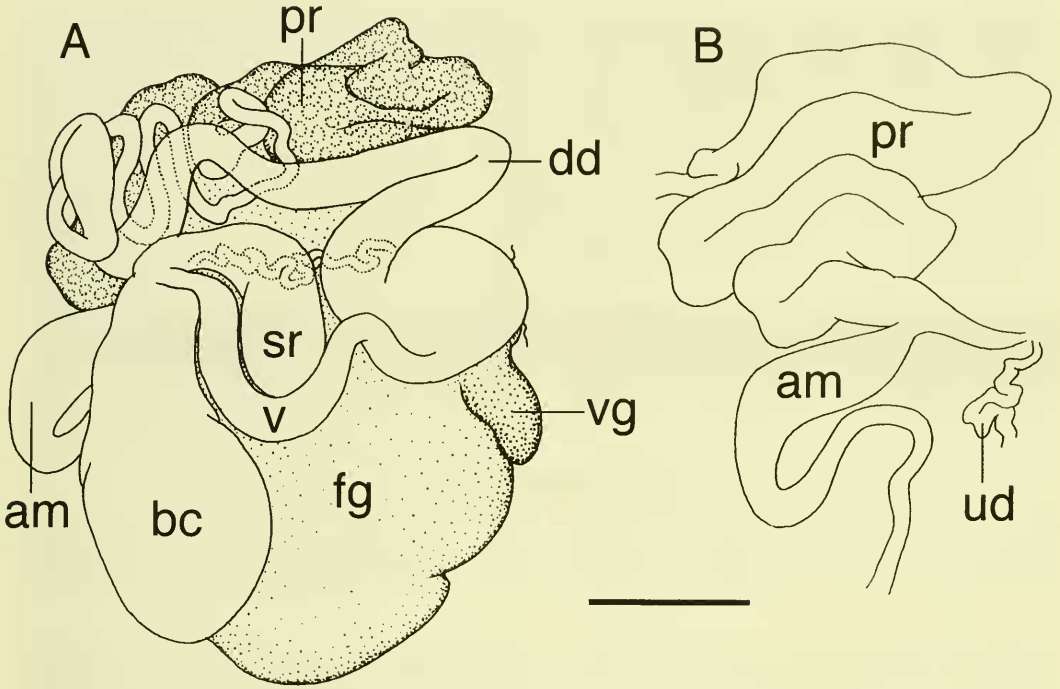


FIGURE 3. *Chromodoris trimarginata* (CASIZ 115219), reproductive system, scale bar = 1 mm. A. General view; B. Detail of several dissected organs. Abbreviations: am = ampulla, bc = bursa copulatrix, dd = deferent duct, fg = female glands, pr = prostate, sr = seminal receptacle, ud = uterine duct, v = vagina, vg = vestibular gland.

inside a slightly wider band of yellow. The rhinophores were described as very pale green with white tips, and the eleven, simply pinnate branchial leaves as white, with the lamellae and rachis opaque white. Rudman (1985) redescribed this species based on the preserved syntypes deposited at the Museum of Natural History of London (BMNH 1960725). He transferred this species to the genus *Chromodoris* and distinguished it from the similar *Chromodoris preciosa* (Kelaart, 1858) and *Chromodoris sinensis* Rudman, 1985, due to differences in color and radular morphology.

The coloration of our specimen from Mandapam resembles the original description of *C. trimarginata* by Winckworth (1946), and the radula is identical to the photographs published by Rudman (1985) for this species.

The present study confirms the differences in color between *C. trimarginata* and *C. preciosa*. The latter has reddish rhinophores and branchial leaves (Kelaart 1858; Rudman 1985), whereas in *C. trimarginata* the rhinophores are cream and white and the branchial leaves are white. Also, the marginal white band of *C. preciosa* is much wider than that of *C. trimarginata*. Another important difference between these two species is in the radular morphology. The radula of *C. preciosa*, figured by Rudman (1985, fig. 17), has much shorter innermost lateral teeth than *C. trimarginata*. Also, in *C. preciosa* the innermost teeth have two or three large, acute denticles on the inner side of the main cusp, whereas in *C. trimarginata* there are three or four smaller, rounded denticles.

*Chromodoris sinensis* differs from *C. trimarginata* in color and radular morphology. The radula of *C. sinensis* figured by Rudman (1985, fig. 18) has large rachidian teeth, and two or three acute denticles on the inner side of the innermost lateral teeth. In *C. trimarginata*, the rachidian teeth are much smaller and the innermost lateral teeth have three or four rounded denticles on the inner side. According to Rudman (1985) the external differences between these two species are: (1) the

translucent white border is much narrower in *C. sinensis* than in *C. trimarginata*; (2) the branchial leaves and rhinophores of *C. sinensis* are edged with red, whereas they are uniformly white in *C. trimarginata*; and (3) the dorsal spots of *C. sinensis* are regular minute orange-brown spots, instead of the irregular reddish spots of *C. trimarginata*. The study of our living specimens of *C. trimarginata* confirmed all these differences, except for the white band, that is also very narrow in *C. trimarginata*. The reproductive system of *C. trimarginata*, here studied for the first time, has a vestibular gland that is absent in *C. sinensis* (see Rudman 1985). In addition, the uterine duct and the seminal receptacle of *C. trimarginata* connect to the vaginal duct near the bursa copulatrix, whereas in *C. sinensis* they connect in the middle of the vagina (Rudman 1985, fig. 15C).

***Chromodoris mandapamensis* sp. nov.**

Figs. 1B, 4, 5

MATERIAL EXAMINED. — HOLOTYPE: Mandapam, Tamil Nadu, India, March 1999, 50 mm long, collected by E. Mollo (CASIZ 115229). PARATYPES: Mandapam, Tamil Nadu, India, May 1998, two specimens 30 mm long, one of them dissected, collected by E. Mollo (CASIZ 115220).

Twenty six additional specimens collected in March 1999 from Mandapam (Tamil Nadu, India) and one specimen collected in May 1998 from Muttom (Kerala, India), were used for chemical studies.

EXTERNAL MORPHOLOGY. — The body is elongate (Fig. 1B). The posterior end of the notum is very elongate and covers the foot. The living animal is cream to pale gray. The entire dorsum is densely covered with numerous, rounded, dark brown spots. These spots appear to be diffuse in the mantle edge. A broken line of bright orange spots edges the mantle margin. There are several, ramified, subepidermal mantle glands around the mantle margin (Fig. 5A). The rhinophore stalks are cream with several dark brown spots. The clubs are brown, with white edged lamellae. The apexes are reddish with white tips. The perfoliate rhinophores are composed of 17 lamellae. The gill consists of seven large, bipinnate branchial leaves. The leaves are pale brown with numerous, small opaque white dots scattered all over the surface, and large brown spots near the base of the leaves.

ANATOMY. — The buccal mass is divided evenly into an anterior glandular portion and a posterior muscular one. At the posterior end of the mass there are a pair of long salivary glands. The jaws are composed of a number of elongate, bifid rodlets (Fig. 4D) about 15  $\mu$ m in length. The radular formula is  $67 \times 53.0.53$  in one specimen (CASIZ 115220) examined. Rachidian teeth are absent. The innermost lateral teeth (Fig. 4A) have two denticles on the inner side of the cusp and three denticles on the outer side. The remaining lateral teeth (Fig. 4B) are hook-shaped, lack denticles on the inner side of the cusp, and have a series of four to six denticles along the outer edge. The outer laterals (Fig. 4C) are elongate with four to seven denticles situated on the tips of the teeth.

The reproductive system (Fig. 5B, C) has a long, tubular ampulla that divides into the oviduct and the prostate. The oviduct is short and enters the female glands near the center of the mass. The prostate is long, tightly coiled with several loops. It narrows and then expands into the muscular deferent duct, which is bulbous distally. The deferent duct is very short and wide, and opens into a common atrium with the vagina. The penis is unarmed. The vagina is short and slightly coiled. The uterine duct emerges near the end of the vagina. The uterine duct is long and opens into the female glands. More proximally there are the curved, club-shaped seminal receptacle and the rounded, thin-walled bursa copulatrix.

ETYMOLOGY. — The name is derived from Mandapam, the type locality of this species.

DISTRIBUTION. — So far, this species is only known from Mandapam (Tamil Nadu) and Muttom (Kerala), southern India.

REMARKS. — *Chromodoris mandapamensis* is externally different from other species of *Chromodoris* previously described.



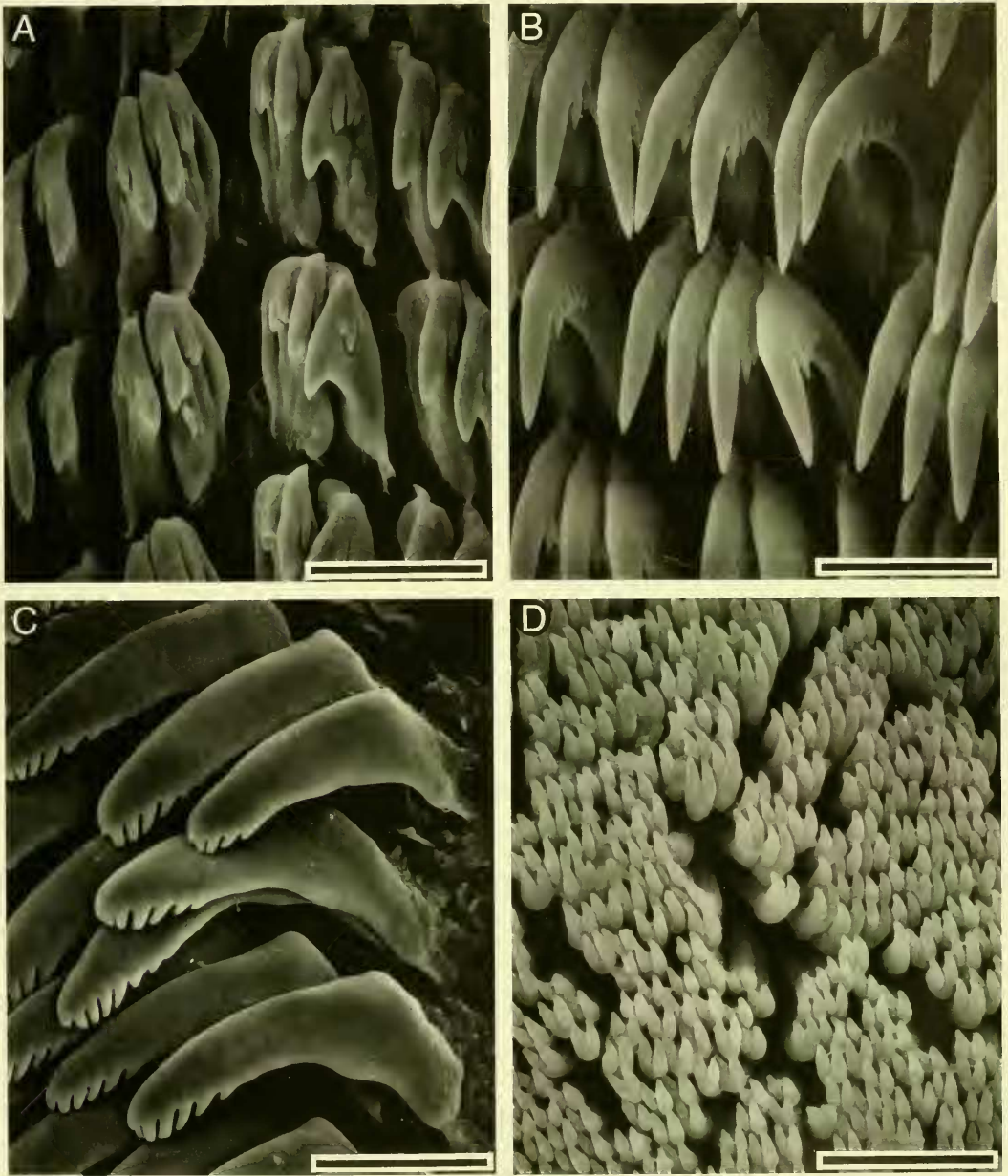


FIGURE 4. *Chromodoris mandapamensis* sp. nov. (CASIZ 115220), scanning electron micrographs. A. Inner lateral teeth, scale bar = 25  $\mu$ m; B. Lateral teeth from the central portion of the half-row, scale bar = 30  $\mu$ m; C. Outer lateral teeth, scale bar = 30  $\mu$ m; D. Jaw rodlets, scale bar = 20  $\mu$ m.

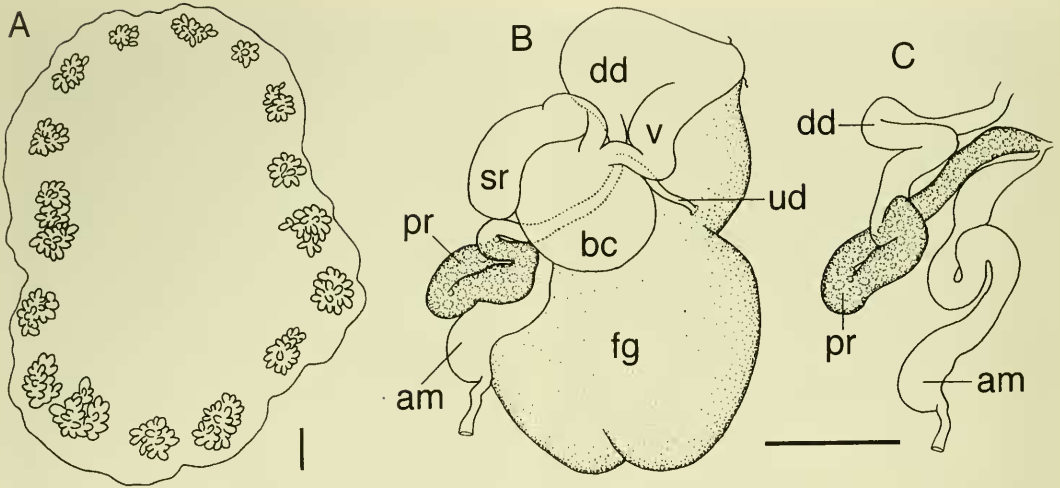


FIGURE 5. *Chromodoris mandapamensis* sp. nov. (CASIZ 115220). A. Disposition of the mantle glands, scale bar = 1 mm; B. General view of the reproductive system, scale bar = 1 mm; C. Detail of several dissected organs, scale bar = 1 mm. Abbreviations: am = ampulla, bc = bursa copulatrix, dd = deferent duct, fg = female glands, pr = prostate, sr = seminal receptacle, ud = uterine duct, v = vagina.

Kelaart (1859b) described *Doris humberti* as a white species with purple and brown spots on the dorsum; white mantle margin with a row of bright red spots, red rhinophores and gill with white spots, nine small branchial leaves irregularly pinnated. This species is clearly distinguishable from *C. mandapamensis*, which has seven very large, brown branchial leaves and dark brown rhinophores. O'Donoghue (1932) redescribed *D. humberti* based on newly collected material from southern India and transferred it to the genus *Glossodoris* Ehrenberg, 1831. O'Donoghue's paper includes a description of the radula that is elongate, with a formula of  $74 \times 46.0.46$ , and has innermost lateral teeth with a single, large denticle on the inner side, and two on the outer side. This is very different from *C. mandapamensis*, which has a formula of  $67 \times 53.0.53$  and the innermost lateral teeth have two denticles on the inner side and three on the outer side.

Two other Indo-Pacific species of *Chromodoris* with a similar coloration to *C. mandapamensis* are *Chromodoris lineolata* (van Hasselt, 1824) and *Chromodoris striatella* Bergh, 1876, redescribed by Rudman (1982) and Rudman and Darvell (1990). These latter two species have a white background color with numerous brown or black lines, and an orange mantle margin. They are clearly distinguishable from *C. mandapamensis*, which has dorsal spots instead of lines.

### *Chromodoris naiki* sp. nov.

Figs. 1C, 6, 7

MATERIAL EXAMINED. — HOLOTYPE: Mandapam, Tamil Nadu, India, May 1998, one specimen 13 mm preserved length, dissected, collected by E. Mollo (CASIZ 115221).

EXTERNAL MORPHOLOGY. — The body is oval (Fig. 1C). The notum covers the posterior end of the foot. The living animal is pale gray-brown, with a pale blue band at the edge of the notum. Along the margin and in the central part of the dorsum, there are scattered large spots of dark purple. Immediately inside the area of outer purple spots there is an area of reflective yellow or orange-yellow mantle glands. There are also yellow or orange-yellow mantle glands (Fig. 6A) associated with the dark purple spots in the center of the dorsum. Numerous, small opaque white spots are scattered all



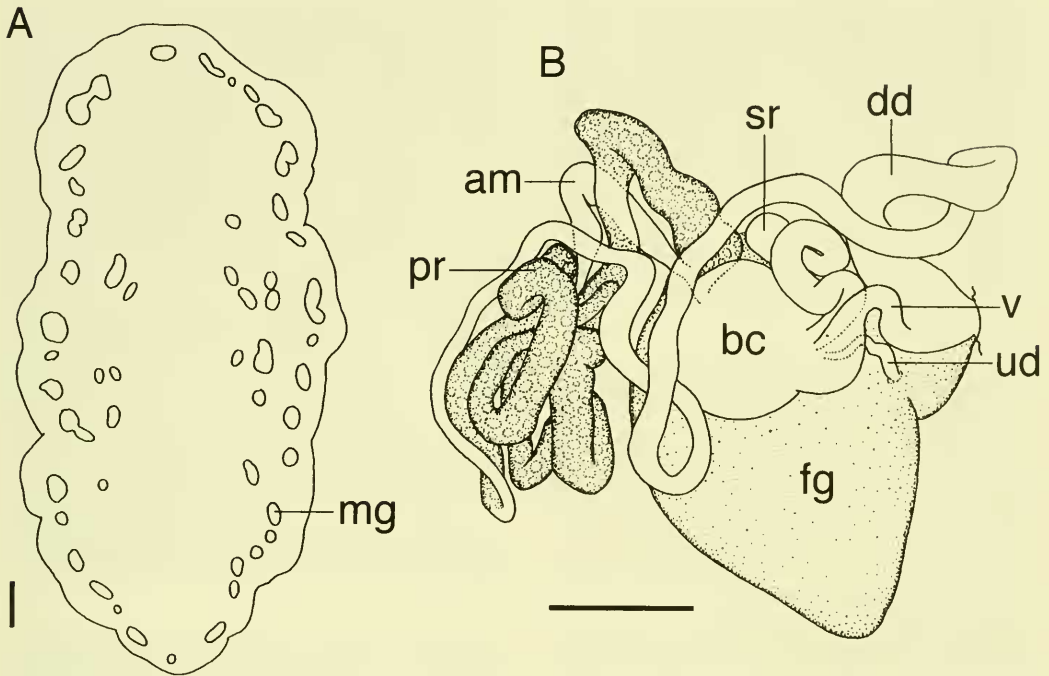


FIGURE 6. *Chromodoris naiki* sp. nov. (CASIZ 115221). A. Disposition of the mantle glands, scale bar = 1 mm; B. General view of the reproductive system, scale bar = 1 mm. Abbreviations: am = ampulla, bc = bursa copulatrix, dd = deferent duct, fg = female glands, pr = prostate, sr = seminal receptacle, ud = uterine duct, v = vagina.

over the central part of the dorsum. The rhinophore clubs and gill are gray-brown. The bases of the rhinophores are translucent gray. There are numerous small opaque white spots arranged in distinct rows along the edges of the rhinophoral lamellae and gill pinnae. The gill consists of six unipinnate branchial leaves. The perfoliate rhinophores are composed of 20 lamellae.

**ANATOMY.** — The buccal mass is divided evenly into an anterior glandular portion and a posterior muscular one. At the posterior end of the mass there are a pair of large, elongate salivary glands. The jaws are composed of a number of elongate, bifid rodlets (Fig. 7E) about 15  $\mu\text{m}$  in length. The radular formula is  $38 \times 41.0.41$  in the holotype (CASIZ 115221). Rachidian teeth are absent. The innermost lateral teeth (Fig. 7A, B) have one large denticle on the inner side of the cusp and three to four denticles on the outer side. The remaining lateral teeth (Fig. 7C) are hook-shaped, lack denticles on the inner side of the cusp and have a series of six to seven denticles along the outer edge. The outer laterals (Fig. 7D) are elongate with six to seven denticles situated on the tips of the teeth.

The reproductive system (Fig. 6B) has an elongate and tubular ampulla that divides into the oviduct and the prostate. The oviduct is very short and enters the female glands near the center of the mass. The prostate is long, tightly coiled with several loops. It narrows into the muscular deferent duct. The deferent duct is also very long and coiled, and opens into a common atrium with the vagina. The penis is unarmed. The vagina is short and wide, slightly coiled. Near the end of the vagina the uterine duct emerges. It is short and convoluted and opens into the female glands. More proximally are the tightly coiled, digitiform seminal receptacle and the rounded, thin-walled bursa copulatrix.

**ETYMOLOGY.** — The species is named after Dr. Chandrakant G. Naik, National Institute of Oceanography, Goa, India, for his support during the field work.

**DISTRIBUTION.** — So far, this species is only known from Mandapam, southern India.

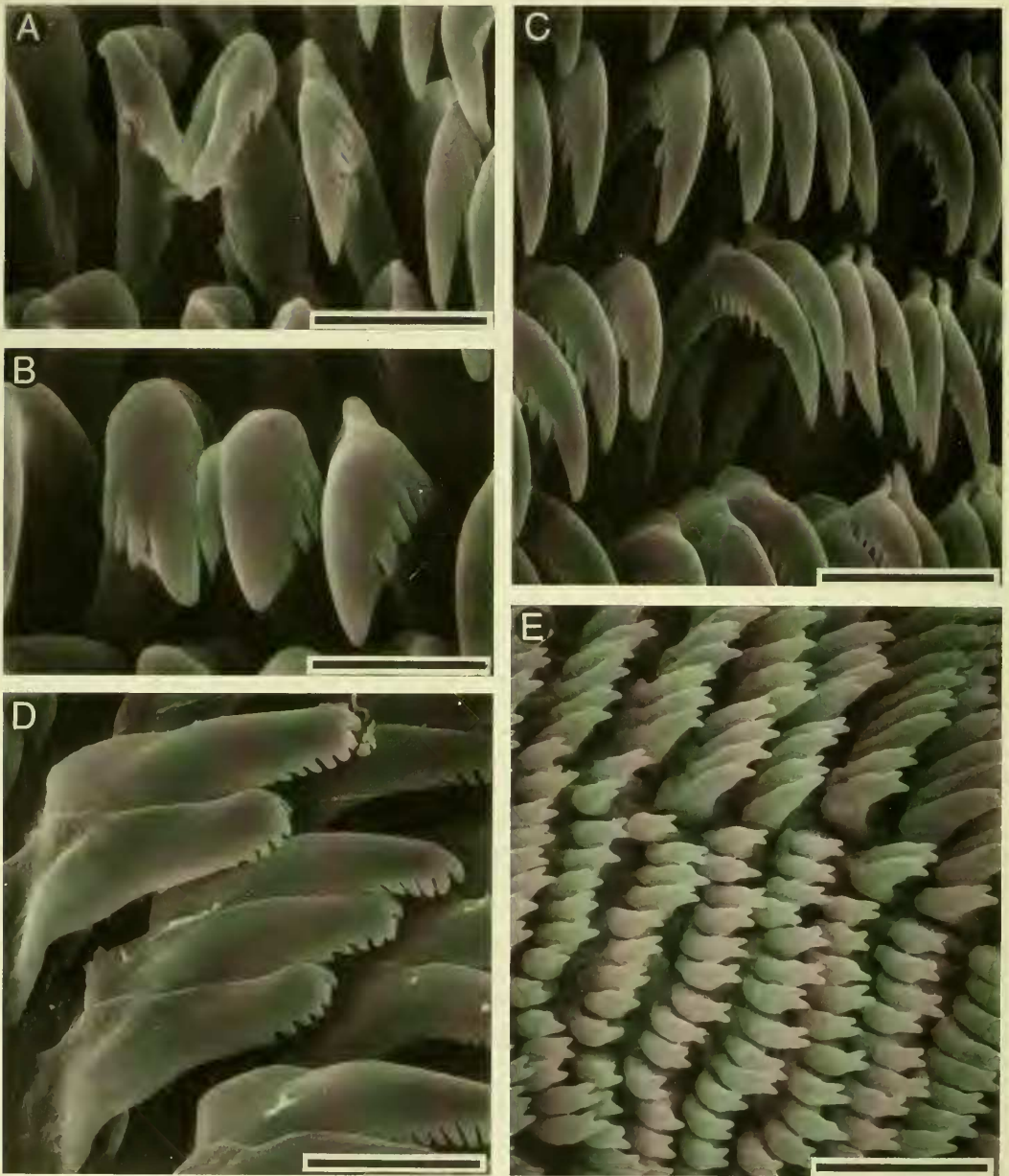


FIGURE 7. *Chromodoris naiki* sp. nov. (CASIZ 115221), scanning electron micrographs. A. Inner lateral teeth, scale bar = 20  $\mu$ m; B. Inner lateral teeth, scale bar = 15  $\mu$ m; C. Lateral teeth from the central portion of the half-row, scale bar = 25  $\mu$ m; D. Outer lateral teeth, scale bar = 25  $\mu$ m; E. Jaw rodlets, scale bar = 20  $\mu$ m.

REMARKS. — *Chromodoris naiki* is externally very similar to *Chromodoris kitae* Gosliner, 1994, described from Madagascar. However, there are several external and internal differences that clearly separate these two species. In *C. kitae* the yellow glands are only present in the mantle margin (see Gosliner 1994), whereas in *C. naiki* they are also in the center of the dorsum, associated with the purple spots. In addition, *C. naiki* has a number of small white spots in the center of the dorsum that

are absent in *C. kitae*. The number of branchial leaves is also different between them: *C. kitae* has eight whereas *C. naiki* has six.

Internally these two species differ in their radular morphology. Whereas *C. kitae* has rachidian teeth, they are absent in *C. naiki*. Also, the innermost lateral teeth of *C. kitae* have one or two small denticles on the inner side, clearly separated from the main cusp, whereas in *C. naiki* there is only one, large denticle situated next to the main cusp. On the outer side of the cusp, *C. kitae* has two to three denticles instead of three to four in *C. naiki*. The mid lateral teeth of *C. naiki* have a much longer cusp than those of *C. kitae*. The reproductive system of *C. kitae* differs from that of *C. naiki* in having a vestibular gland and a short, stalked seminal receptacle.

#### ACKNOWLEDGMENTS

We are very grateful to Dr. Chandrakant G. Naik and all the staff of the National Institute of Oceanography, Goa, India, for their support during the field work. Terry Gosliner, Rebecca Johnson and one anonymous reviewer made constructive comments on the manuscript.

Financial support for field work was made possible by an agreement between the Istituto per la Chimica di Molecole di Interesse Biologico (CNR), Naples, Italy and the National Institute of Oceanography, Goa, India. This paper has also been supported by the Ministerio de Educación y Cultura of Spain (SEUI), through its postdoctoral fellowships program.

#### LITERATURE CITED

- ALDER, J. AND A. HANCOCK. 1964. Notice of a collection of nudibranchiate Mollusca made in India by Walter Elliot, Esq., with descriptions of several new genera and species. Transactions of the Zoological Society of London 5:113–147, pls. 28–33.
- ELIOT, C. 1906a. On the nudibranchs of southern India and Ceylon, with special reference to the drawings by Kelaart and the collections belonging to Alder and Hancock preserved in the Hancock Museum at Newcastle-on-Tyne. Proceedings of the Zoological Society of London 1906:636–691, pls. 42–47.
- . 1906b. On the nudibranchs of southern India and Ceylon, with special reference to the drawings by Kelaart and the collections belonging to Alder and Hancock preserved in the Hancock Museum at Newcastle-on-Tyne. No. II. Proceedings of the Zoological Society of London 1906:999–1008.
- . 1910. Notes on nudibranchs from the Indian Museum. Records of the Indian Museum 5:247–252, pl. 19.
- FARRAN, G. P. 1905. Report on the opisthobranchiate Mollusca collected by Professor Herdman, at Ceylon, in 1902. Ceylon Pearl Oyster Fisheries, Supplementary Reports, 21:329–364, pls. 1–6.
- GOSLINER, T. M. 1994. New species of *Chromodoris* and *Noumea* (Nudibranchia: Chromodorididae) from the western Indian Ocean and southern Africa. Proceedings of the California Academy of Sciences 48(12):239–252.
- KELAART, E. F. 1858. New and little known species of Ceylon nudibranchiate molluscs, and zoophytes. Journal of the Royal Asiatic Society, Ceylon Branch 3:84–139, 2 pls.
- . 1859a. Descriptions of new and little-known species of Ceylonese nudibranchiate mollusks. Annals and Magazine of Natural History (3)3:291–304.
- . 1859b. On some additional species of nudibranchiate mollusks from Ceylon. Annals and Magazine of Natural History (3)4:267–270.
- NARAYANAN, K. R. 1969. On the opisthobranchiate fauna of the Gulf of Kutch. Pp. 188–213 in Proceedings of the Symposium on Mollusca held at Cochin. I. Marine Biological Association of India, Mandapam, India.
- O'DONOGHUE, C. H. 1932. Notes on nudibranchiata from southern India. Proceedings of the Malacological Society of London 20:141–166.
- RUDMAN, W. B. 1973. Chromodorid opisthobranch Mollusca from the Indo-West Pacific. Zoological Journal of the Linnean Society 52:175–199, pls. 1–2.



- . 1982. The Chromodorididae (Opisthobranchia: Mollusca) of the Indo-West Pacific: *Chromodoris quadricolor*, *C. lineolata* and *Hypselodoris nigrolineata* colour groups. Zoological Journal of the Linnean Society 76:105–173.
- . 1985. The Chromodorididae (Opisthobranchia: Mollusca) of the Indo-West Pacific: *Chromodoris aureomarginata*, *C. verrieri* and *C. fidelis* colour groups. Zoological Journal of the Linnean Society 83:241–299.
- RUDMAN, W. B. AND B. W. DARVELL. 1990. Opisthobranch molluscs of Hong Kong. Part 1: Goniodorididae, Onchidorididae, Triophidae, Gymnodorididae, Chromodorididae (Nudibranchia). Asian Marine Biology 7:31–79.
- WHITE, K. M. 1948. On a collection of marine molluscs from Ceylon. Proceedings of the Malacological Society of London 27:199–205.
- WINCKWORTH, H. C. 1945. *Glossodoris* from Bombay. Proceedings of the Malacological Society of London 26:155–160.